



Fermilab



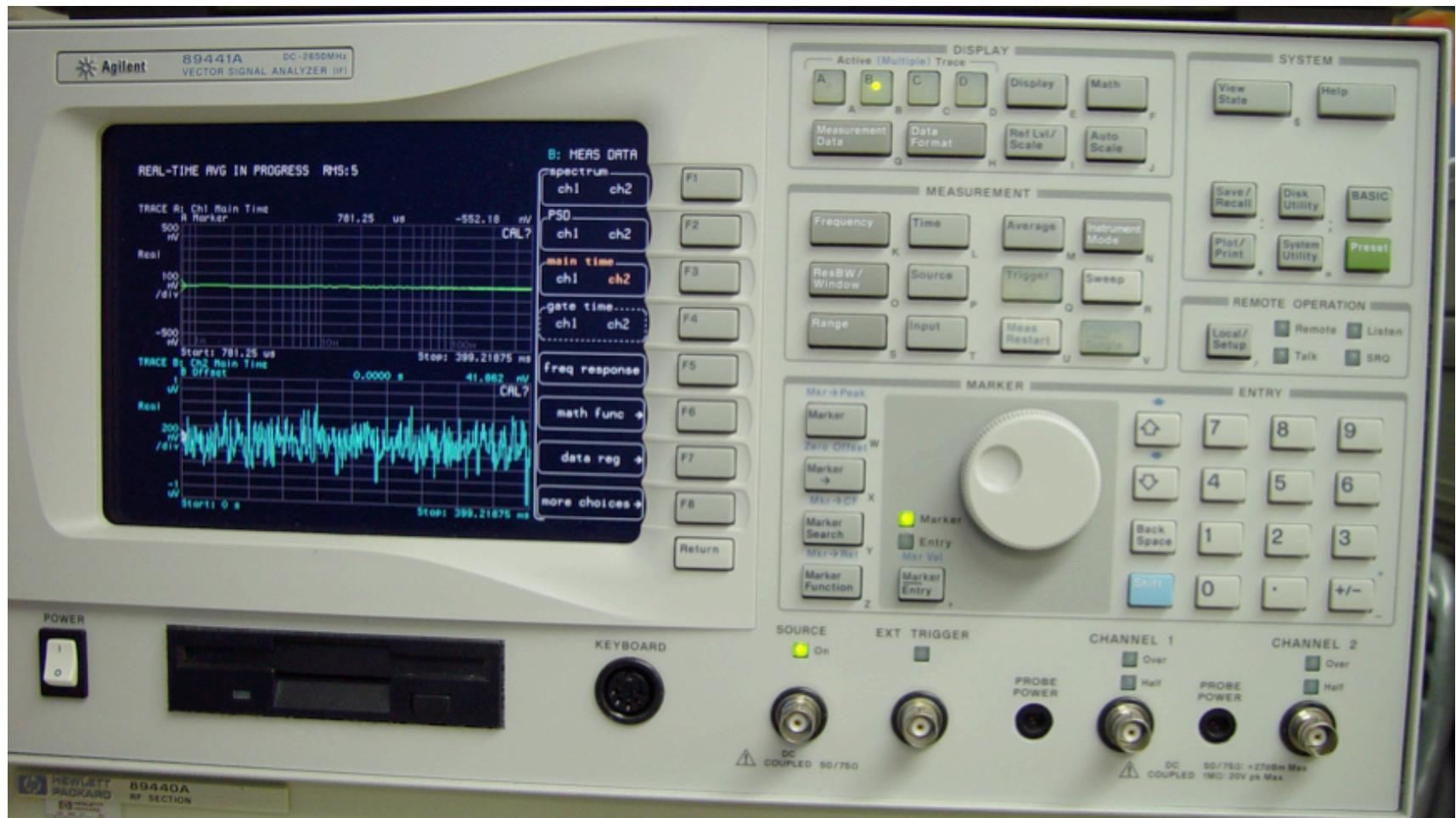
Vector Signal Analyzer

VSA

Ralph J. Pasquinelli



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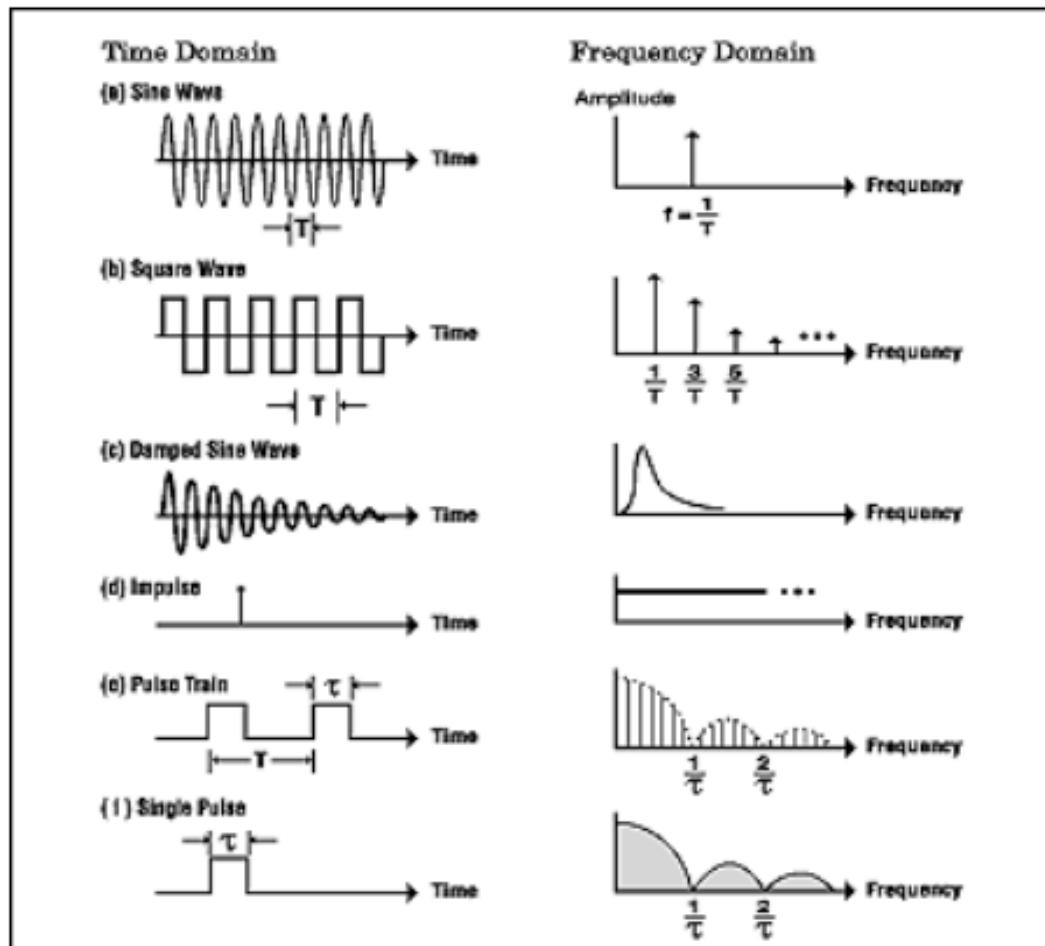


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Fourier Transform

$$V(f) = \int_{-\infty}^{\infty} v(t) e^{-j2\pi ft} dt$$



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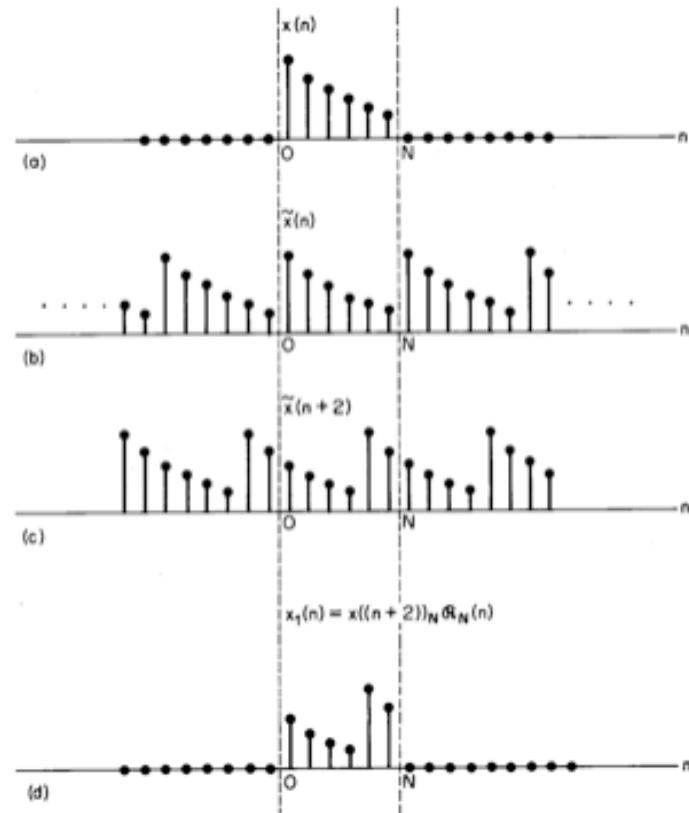
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Discrete Fourier Transform DFT

$$X(k) = \begin{cases} \sum_{n=0}^{N-1} x(n) W_N^{kn}, & 0 \leq k \leq N-1 \\ 0, & \text{otherwise} \end{cases}$$

where $W_N = e^{-j(2\pi/N)}$

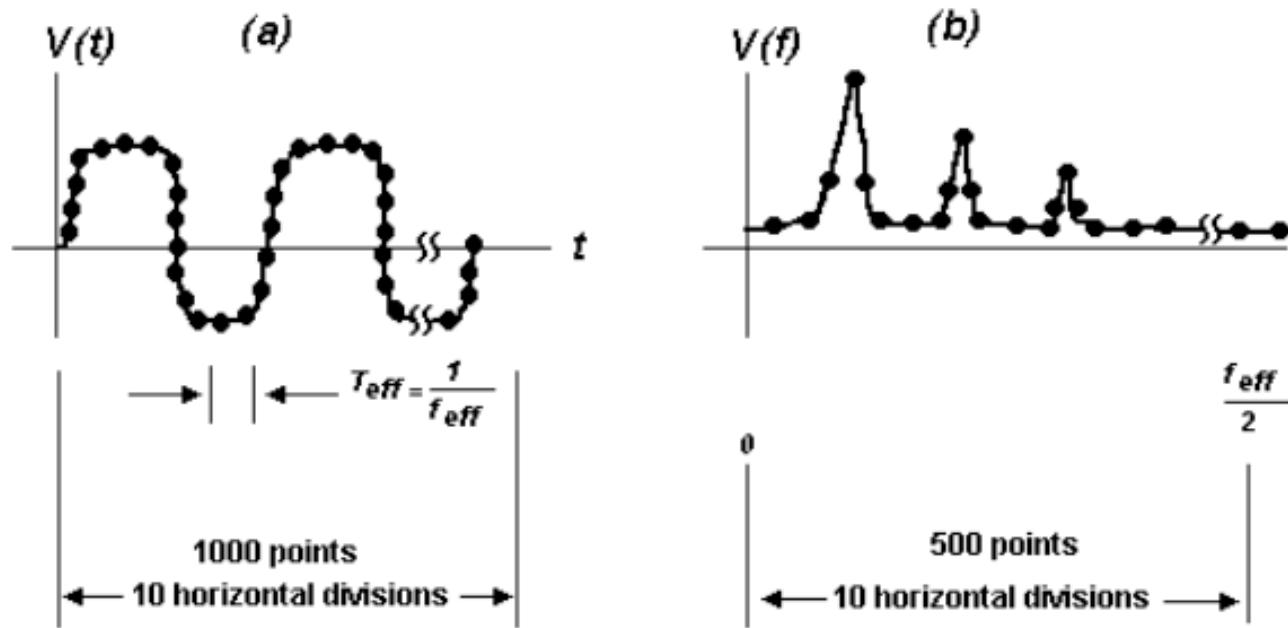
The Discrete Fourier Transform





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Fast Fourier Transform FFT



3a).

Figure 3

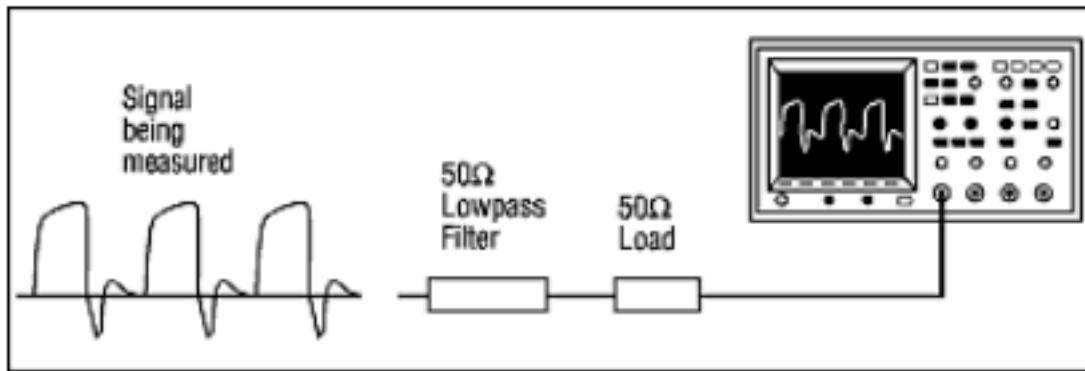
- (a) The sampled time domain waveform.
- (b) The resulting frequency domain plot using the FFT.

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Aliasing

All Frequencies above $f_{eff}/2$ will fold down into the FFT
And are referred to as aliasing. Input signal must always be
Sampled at least twice the highest frequency component
i.e. the Nyquist criteria. A low pass filter before the digitizer
Called an anti-aliasing filter will limit the frequency response.



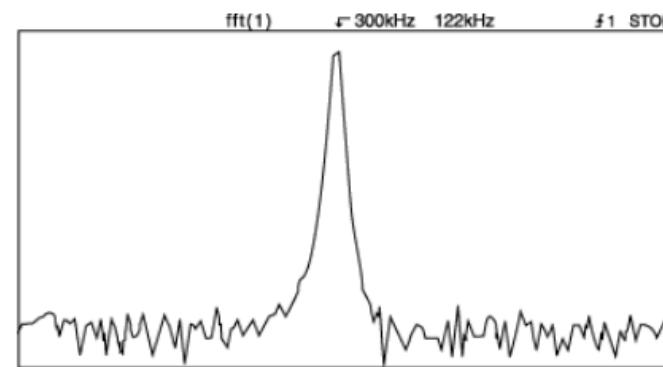
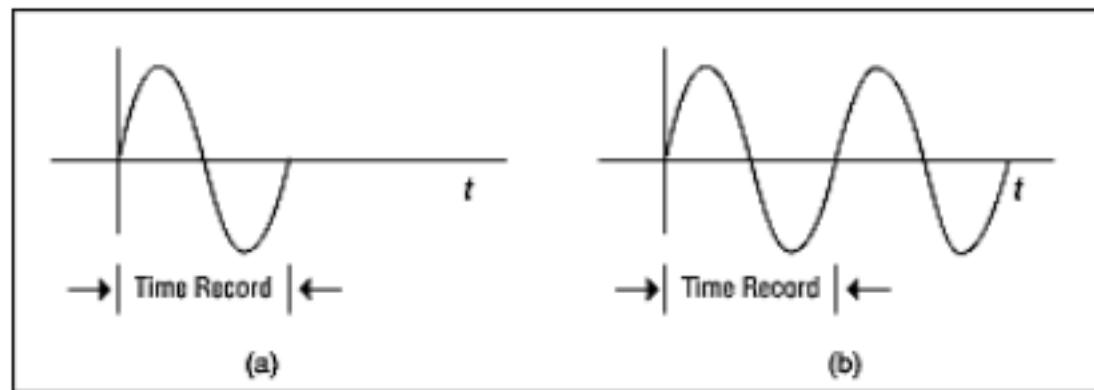
A **lowpass filter** can be used to band limit the signal, avoiding aliasing.



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No transients in record



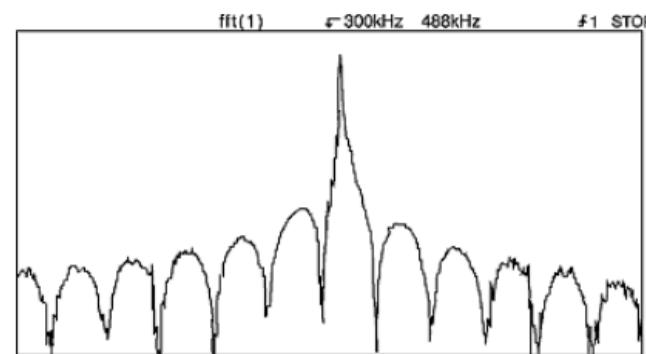
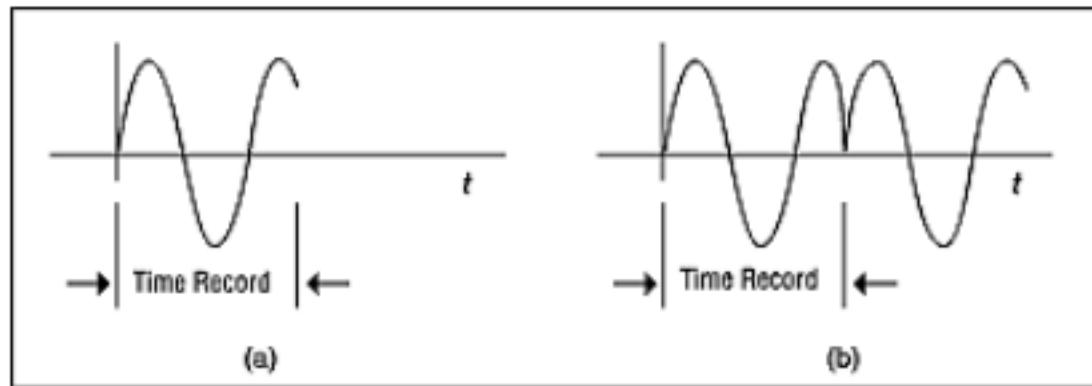
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Transient in record creates “leakage”

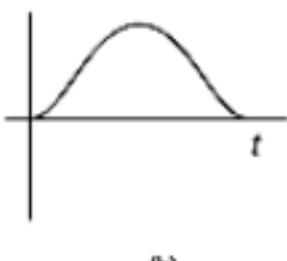
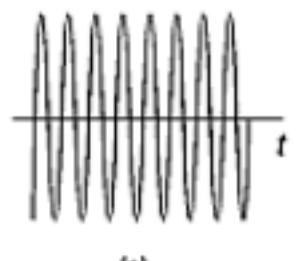


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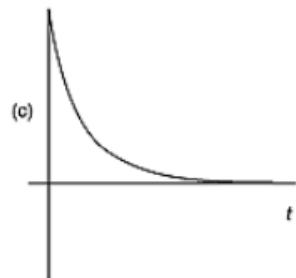
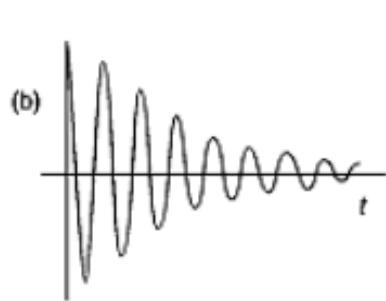


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Windowing



Hanning Window
Good frequency
Resolution poorer
Amplitude resolution

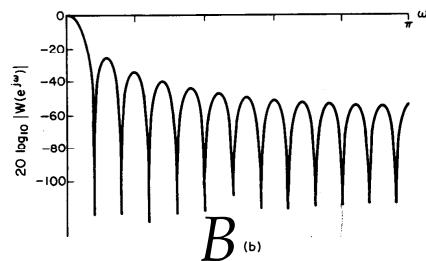
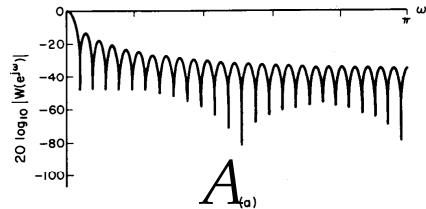


Exponential Window
For transients

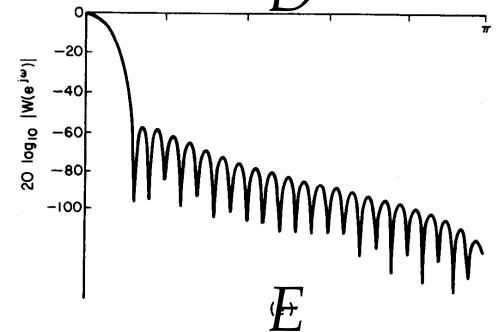
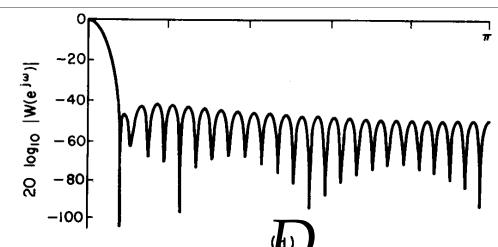
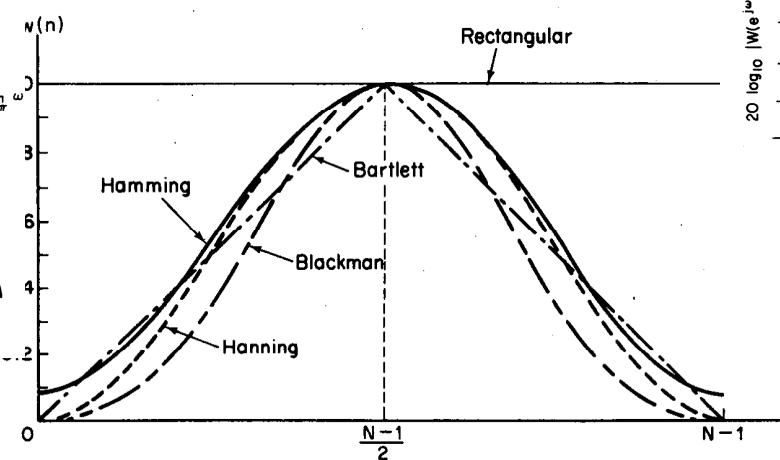


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More Windows



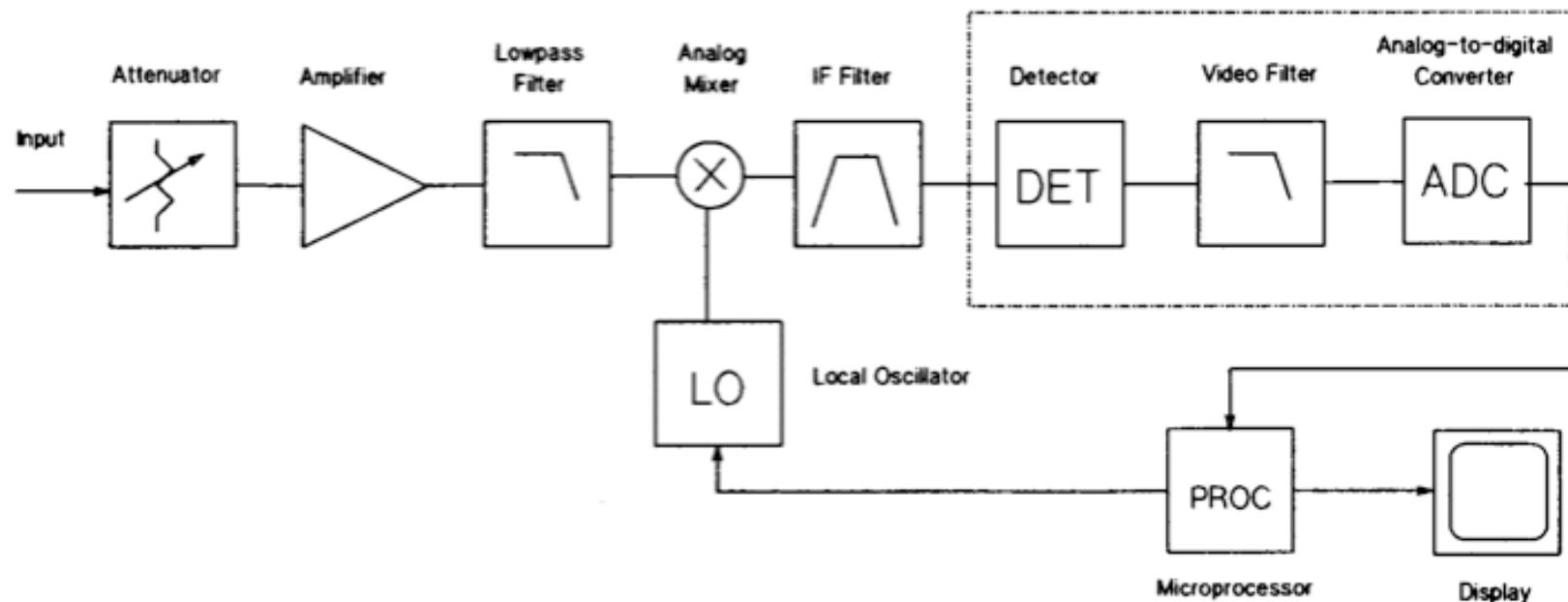
- A Rectangular
- B Triangular
- C Hanning
- D Hamming
- E Blackman





Swept tuned analyzer

Analog IF Section

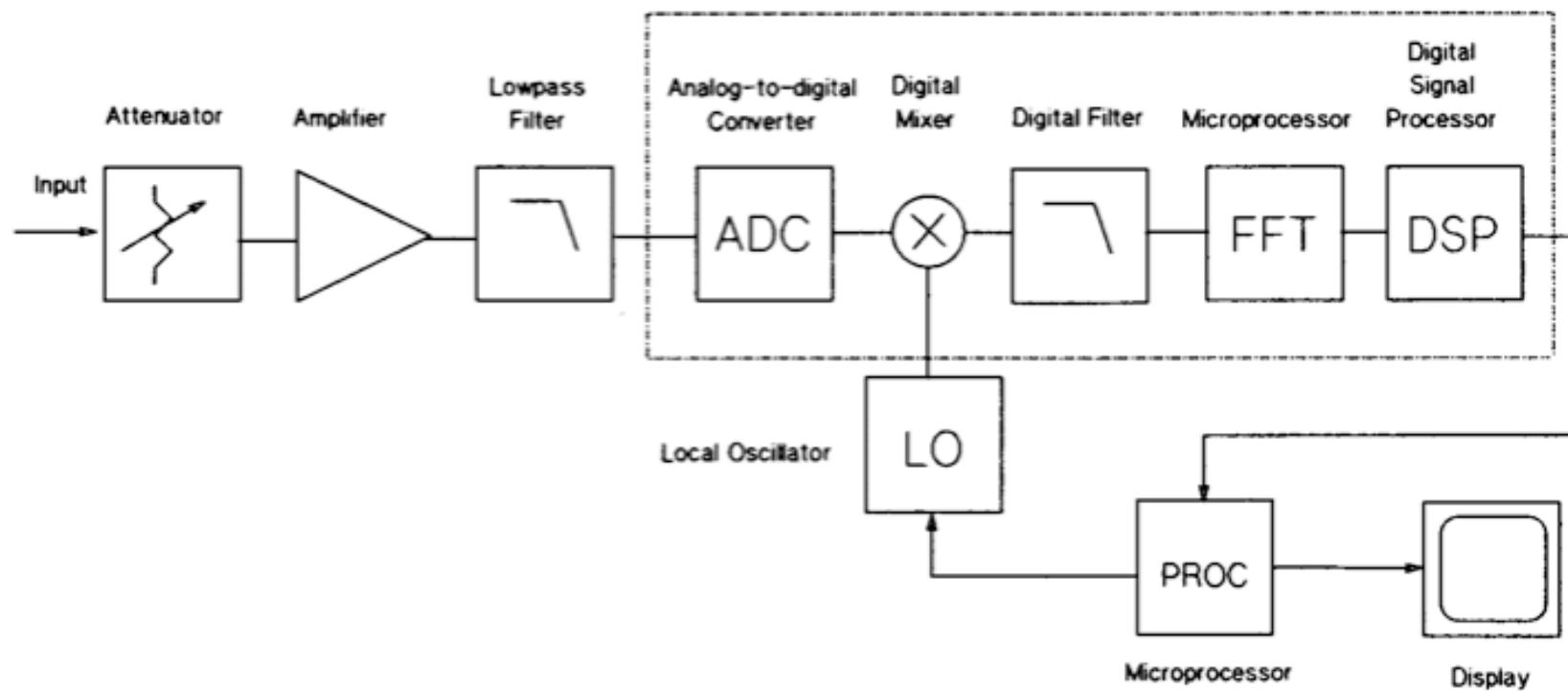




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VSA analyzer

Digital IF Section



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■ *Multiple Modes of Operation*

■ *Scalar Mode*

- | *Identify signals in wide span or small signals close to the noise floor, similar to swept tuned spectrum analyzer: measure oscillator harmonic distortion*

■ *Vector Mode*

- | *Analyze signals with phase and time data, fast transforms between time and frequency domain: measure oscillator side bands or phase noise*

■ *Demodulation Mode*

- | *Characterize amplitude, frequency and phase relationships: characterize oscillator sideband noise as AM or PM*



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■ *Specifications*

- *Frequency response DC-10 MHz*
- *Span 1Hz to 10 MHz*
- *51-3201 points per span*
- *Frequency tuning 0.001 Hz*
- *Resolution Bandwidth 312.5 uHz to 3 MHz*
- *Dynamic Range 75 dBc minimum*
- *Maximum input power +24 dBm*
- *Input capture buffer up to 1 MBit*



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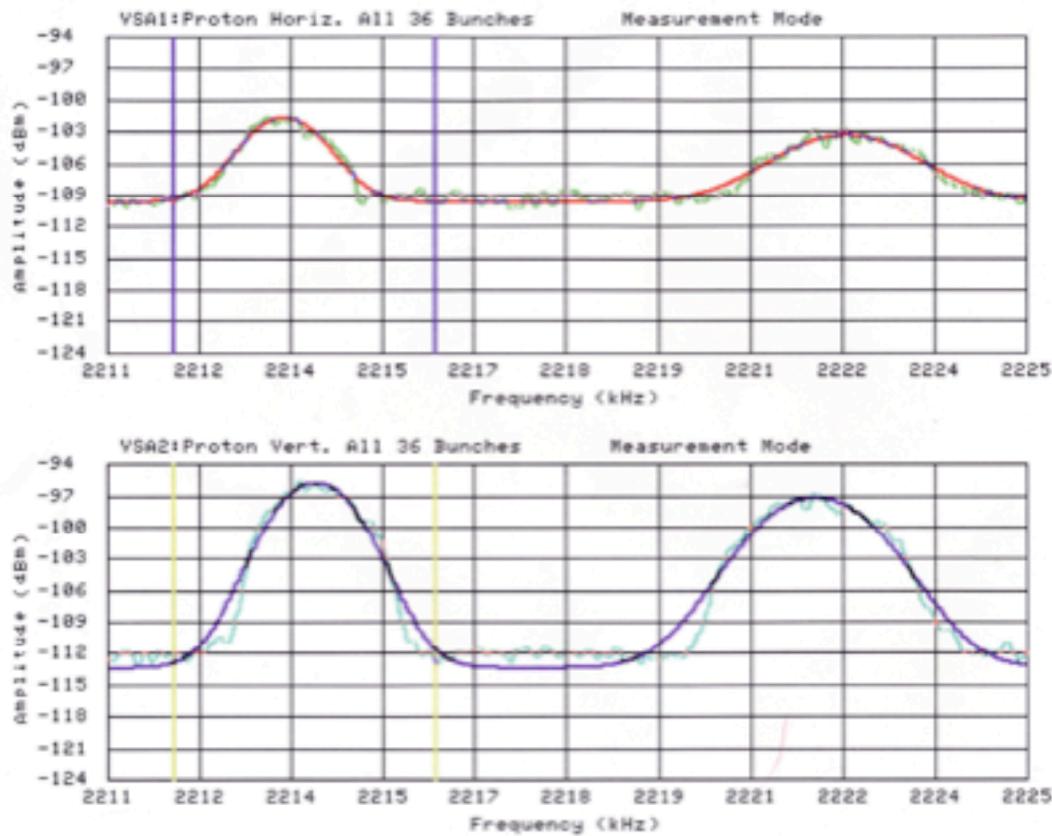
■ *Features*

- *Real time frequency analysis*
- *Fast measurements at narrow RB, up to 1000x faster than swept tuned spectrum analyzer*
- *Spectrogram allows for frequency spectrum vs time*
- *Water fall running plot of spectrums for transients*
- *Time capture buffer for post analysis*
- *Two input channels*
- *With internal source capable of transfer functions*



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Tevatron 1.7 GHz Schottky Monitor



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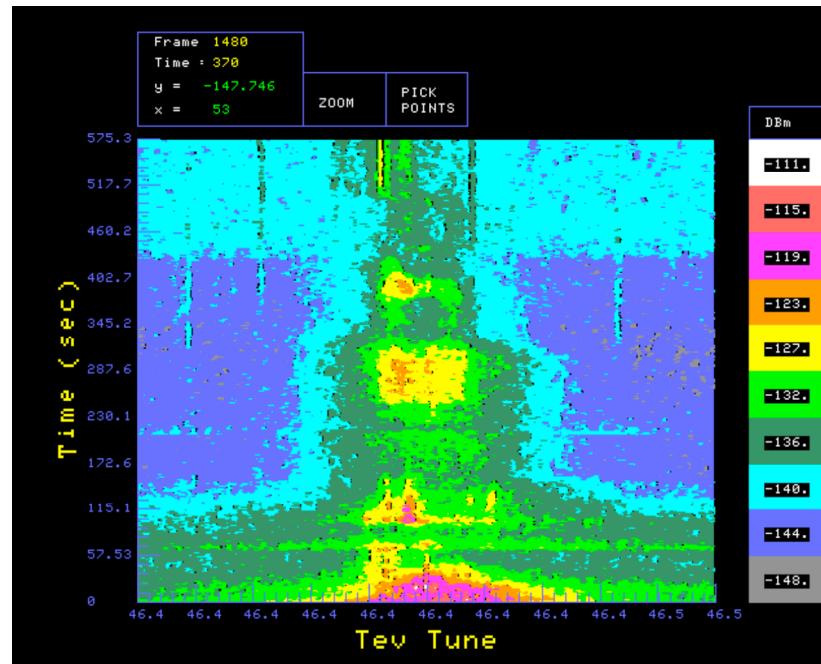


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Tevatron 1.7 GHz Schottky Spectrogram



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References

*Digital Signal Processing, Oppenheim & Schafer,
1975 Prentice Hall*

Agilent educators corner

[Fourier Theory & Practice, Part I: Theory \[Exp53a.pdf\]](#)

Fourier Theory & Practice, Part I: Theory (Agilent Product Note **54600-4**) By:

Robert Witte Agilent Technologies Introduction: This product note provides a brief review of Fourier theory, especially the unique behavior of the FFT. The note also describes some typical applications and provides some ...

<http://www.educatorscorner.com/media/Exp53a.pdf> 04/09/03, 280197 bytes

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